PLEISTOCENE MOLLUSCAN FAUNAS OF THE HUMBOLDT DEPOSIT, ROSS COUNTY, OHIO

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Location of Deposit

The Humboldt deposit is located 0.4 mi north of BM 798 at Humboldt, on Ohio Highway 41, Paint Township, Ross County, Ohio; Greenfield Quadrangle, southeast rectangle, at approximately 39° 16.87' north latitude and 83° 18.85' west longitude (fig. 1). It lies approximately 75 yd east of Ohio Highway 41 and is visible from the road only during the months when little or no foliage is present. The brightly colored gravel at the base of the section serves to distinguish this deposit since it is not exposed anywhere else in the immediate vicinity.

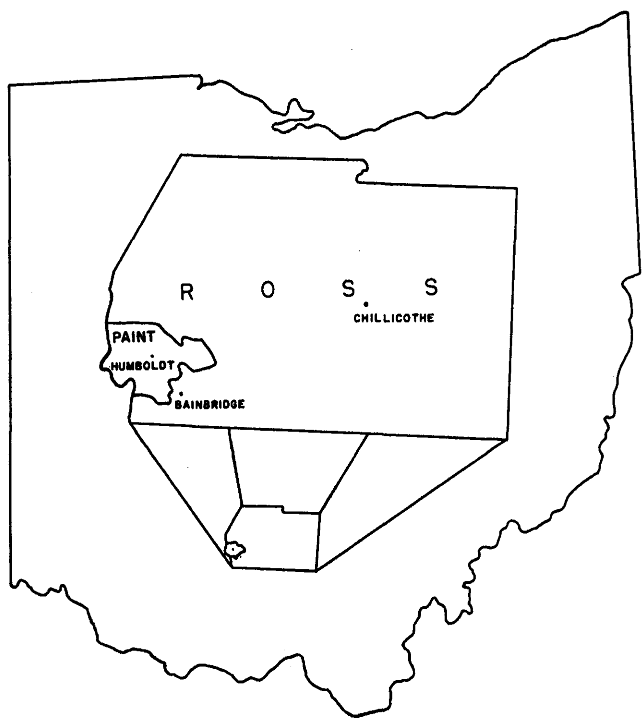

FIGURE 1. Index map, showing location of Humboldt deposit.

Methods of Investigation

The Humboldt deposit was sampled at two inch intervals. Each of the samples collected measured approximately 12 x 12 x 2 in. or 288 cu in. As the samples were collected they were numbered, placed in plastic bags, and sealed in order to maintain their moisture content.

In the laboratory, samples were placed in 2,000 ml beakers, covered with water, and allowed to stand from 24 to 48 hr. After soaking, the samples were washed through a series of sieves, separated into coarse, medium, fine, and very fine fractions and allowed to dry. When dry, they were placed in containers and appropriately labeled.

The volume of shell material and matrix for each of the sections was quite large, in excess of three pints in some cases; their volume was reduced by quartering with a special device designed for that purpose. The unsorted material was passed through the quartering device and only a fraction of the original volume was retained to be sorted. The fraction retained depended upon the fossil content of the sample. Approximately 1,000 shells were selected at random from each of the fossiliferous sections.

Stratigraphy

The Humboldt deposit lies near the limit of continental glaciation in the low-lying Appalachian Plateau district of southern Ohio. It is an area that has been glaciated twice; both the Illinoian and Wisconsin glaciers considerably modified Buckskin Creek valley and filled it with a thick deposit of till and outwash.

The Humboldt section consists of nine units. The first three are composed of gravel, till, and sand and gravel, respectively, followed by the lacustrine deposits which compose units four through eight. Unit eight is overlain by a dark brown, blocky clay that is noncalcareous and contains numerous black shale fragments. The lake beds compose four ft of the total 32 ft in the measured section. They are typical in that they exhibit rapid lateral changes in lithology and considerable variation in thickness. They increase from four to ten ft in thickness when traced south and east of the measured section.

The extent of the Humboldt deposit is for the most part undetermined. It appears to be confined to the east valley wall; however, unfossiliferous clays and silts of freshwater origin are exposed on the west side of the valley and they may or may not be of comparable age. The fossiliferous lake beds were traced approximately 500 ft south and 100 ft east of the measured section and in both instances disappeared under thick deposits of colluvium.

The Humboldt area is characterized by steep slopes and local relief of the order of 500 ft. Both factors have greatly facilitated the large amounts of colluvial movement and slumping that have taken place in the valley. Because of this movement, exposures are limited, the best ones occurring in road cuts and near abandoned gravel pits.

The mollusk-bearing strata in the Humboldt deposit lie between units four and eight. The abundance of Mollusca increases upward; unit five is only slightly fossiliferous and unit six is more fossiliferous than unit five but considerably less so than unit seven (fig. 2).

Measured Section

Unit	Description	Thickness (inches)
9.	Clay, brown, blocky, noncalcareous, unfossiliferous	72
8.	Peat, black, clayey, blocky, noncalcareous, unfossiliferous	4
7.	Marl, reddish-brown to buff, calcareous, highly fossiliferous	17
6.	Silt, gray-blue, clayey, calcareous, fossiliferous	15
5.	Silt, buff, clayey, calcareous, slightly fossiliferous	6
4.	Silt, reddish-brown, clayey, calcareous, laminated, unfossiliferous; forms sharp contact with underlying sand and gravel	6
3.	Sand and gravel, buff to brown, calcareous, reddish-brown in places, contains dolomite ghosts, unfossiliferous	48
2.	Till, oxidized, brown, silty loam texture, calcareous, blocky structure not well-developed, unfossiliferous	96
1.	Gravel, coarse, calcareous, well-bedded, unfossiliferous	120+

Base of section not exposed.

Quantitative Distribution

The Mollusca of the Humboldt deposit are unevenly distributed from the quantitative standpoint. As may be expected, there is a definite correlation between the abundance of individuals and the lithology. In studying these specimens, the writer observed the presence of two major trends, from which there are several minor variations. The total species in the deposit number 18 (table 1); of these, ten occur more abundantly in the lower, more silty part of the section (collections ten through 18), seven in the upper, marly part (collections one through nine), and the remaining species is found in like numbers in both parts. *Amnicola leightoni*, *Gyraulus altissimus*, *Helisoma anceps striatum*, and

Unit Number	Collection Number	Total Individuals
8	1	0
7	2	5,905
	3	10,500
	4	21,000
	5	27,000
	6	58,000
	7	75,000
	8	120,000
	9	64,800
6	10	6,000
	11	2,273
	12	3,167
	13	2,133
	14	2,125
	15	1,000
	16	1,000
5	17	338
4	18	0

FIGURE 2. Quantitative distribution of Mollusca in the Humboldt deposit.

Valvata tricarinata are the most abundant species in this deposit; together, they form from 85 to 90 percent of the total fauna in each of the fossil-bearing strata. The writer assumes that the more significant species are those which form the largest proportion of the fauna although the lesser elements must not be overlooked; therefore, the above-mentioned species become the more significant forms. Three of them, however, occur more abundantly in the upper part of the deposit, and as this has ecological significance, it will be discussed later.

Before examining the quantitative distribution in detail, a complete understanding of the relationship between the stratigraphic units and the collections is necessary. Collection 18 was taken from unit four, the reddish-brown, unfossiliferous silt; collection 17 was taken from unit five, the buff, slightly fossiliferous silt; collections ten through 16 were taken from unit six, the gray-blue, fossiliferous silt; collections two through nine were taken from unit seven, the reddish-brown to buff, fossiliferous marl; collection one was taken from unit eight, the black, unfossiliferous peat (fig. 2). In general, collections were taken at two-inch intervals; however, units four and five were so well indurated that another sampling technique was required and collections from these units were taken with chisel and hammer.

TABLE 1

Composition of fauna

Pelecypoda	Gastropoda
Pisidium compressum Prime	*Amnicola leightoni* F. C. Baker
Pisidium nitidum Jenyns	*Campeloma* sp., cf. *C. rufum* (Haldeman)
Pisidium nitidum pauperculum (Sterki)	*Ferrissia tarda* (Say)
Pisidium obtusale (Lamarck)	*Fossaria obrussa decampi* (Streng)
Pisidium variabile Prime	*Gyraulus altissimus* (F. C. Baker)
Sphaerium striatinum (Lamarck)	*Helisoma anceps striatum* (F. C. Baker)
Sphaerium sulcatum (Lamarck)	*Helisoma trivolvis* (Say)
	Menetus opercularis multilineatus (Vanatta)
	Physa gyrina (Say)
	Promenetus exacuous (Say)
	Valvata tricarinata (Say)

The following species occur more abundantly in the lower part of the deposit: *Valvata tricarinata*, *Campeloma* sp., cf. *C. rufum*, *Fossaria obrussa decampi*, *Pisidium compressum*, *P. nitidum*, *P. nitidum pauperculum*, *P. obtusale*, *P. variabile*, *Sphaerium striatinum*, and *S. sulcatum*.

The abundance of the majority of the species in the Humboldt deposit appears to be controlled by lithologic changes (fig. 3). The species *Valvata tricarinata* varies from 0 to 7.30 percent in collections one through nine; however, in collection ten there is a marked increase to 32.20 percent. Further, there is a noticeable decrease from collection 16 to collection 17 which also corresponds to a change in lithology. *Campeloma* sp., cf. *C. rufum* is one of the lesser elements of the Humboldt fauna. The majority of the specimens are concentrated in collections 12 through 16; however, this species never composes more than 0.90 percent of the total fauna. *Fossaria obrussa decampi* is distributed throughout the deposit. Its abundance does not appear to be much affected by lithologic changes. In general, it is more abundant in collections 11 and 12 and decreases gradually downward. All the species of *Pisidium* reach their greatest abundance in unit six. *P. nitidum*, *P. obtusale*, and *P. variabile* each compose less than one percent of the total fauna. *P. compressum* and *P. nitidum pauperculum* are the most abundant representatives of the genus, and they also conform rather well with changes in the lithology (fig. 4 and 6). Both species reach their greatest abundance in collections 13, 14, and 15. *Sphaerium striatinum* and *S. sulcatum* are confined entirely to unit six. They occur in collections 11 through 15 and reach their greatest abundance in collection 14; however, they never compose more than 0.50 percent of the total fauna.

The following species occur more abundantly in the upper part of the deposit: *Amnicola leightoni*, *Gyraulus altissimus*, *Helisoma anceps striatum*, *H. trivolvis*, *Physa gyrina*, *Menetus opercularis multilineatus*, and *Ferrissia tarda*. *Amnicola leightoni* is unique in that it is the only significant species to reach its greatest abundance in the upper part of unit seven (fig. 4). Also, little correlation exists between the abundance of this species and the lithology. Instead of decreasing from collection nine to collection ten, the species increases approximately ten percent; it then declines to 23.70 percent in collection 16. Again this species behaves differently from the remaining species and increases more than 40 percent from collection 16 to collection 17. This is best explained by considering the nature and the number of individuals present. The specimens from this collection

Coll. Number	Number of Individuals	Percent Total	10 20 30 40 50 60 70
1	0	0.00	
2	49	4.86	
3	51	5.00	
4	63	6.30	
5	51	5.10	
6	23	2.25	
7	14	1.39	
8	23	2.30	
9	73	7.30	
10	322	32.20	
11	364	36.40	
12	362	36.20	
13	366	34.69	
14	376	37.04	
15	356	34.90	
16	283	28.30	
17	37	10.95	
18	0	0.00	

FIGURE 3. Quantitative distribution of *Valvata tricarinata* in the Humboldt deposit.

are so fragmentary that identification is exceedingly difficult, and as only 338 individuals are present, the writer is inclined to doubt the validity of this sample. The change in lithology between collections nine and ten directly influences the abundance of *Gyraulus altissimus*, for there is an increase from 14.70 percent to 36.20 percent. On the other hand, the increase from collection 17 to collection 16 is negligible (fig. 5). *Helisoma anceps striatum*, like *Gyraulus altissimus*, reaches its greatest abundance in the lower part of unit seven, and from this point decreases, with minor variations, in both directions (fig. 6). *Helisoma trivolvis* is confined entirely to unit seven. It occurs in collections seven, eight, and nine but never exceeds 0.30 percent of the total fauna. *Physa gyrina* is the most unevenly distributed species in the Humboldt deposit. Little or no correlation can be drawn between its distribution and the lithology. Although it is not one of the more significant species, it is certainly one of the more common, for it appears in each of the fossil-bearing strata. *Menetus opercularis multilineatus* is found only in collections two, three, and six. It attains its greatest abundance in collection two where it composes 0.60 percent of the total fauna. *Ferrissia tarda* occurs in both the lower and upper parts of the Humboldt deposit. However, 24 of the

Coll. Number	Number of Individuals	Percent Total
1	0	0.00
2	687	68.22
3	775	75.83
4	795	79.50
5	768	76.80
6	491	48.24
7	435	43.07
8	303	30.30
9	289	28.90
10	383	38.30
11	266	26.60
12	271	27.10
13	227	21.51
14	150	14.78
15	150	14.71
16	237	23.70
17	227	67.16
18	0	0.00

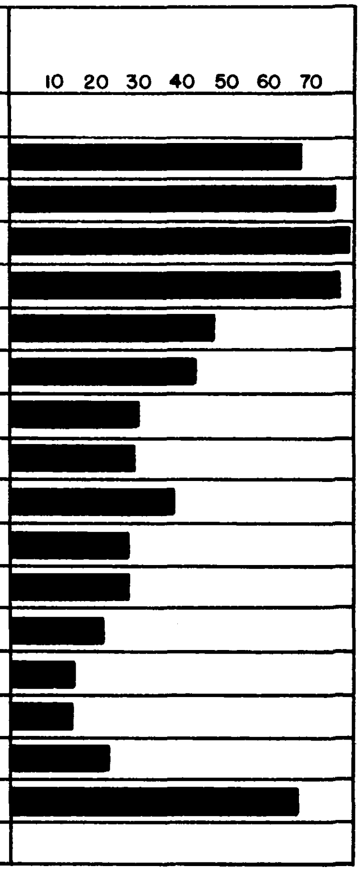

FIGURE 4. Quantitative distribution of *Amnicola leightoni* in the Humboldt deposit.

26 individuals present are found in collections two through six. *Promenetus exacuous* occurs in like numbers in both parts of the deposit; one specimen from collection 17, and one specimen from collection two.

A correlation exists not only between the lithology and the abundance of species, but also between the lithology and the total number of individuals in each of the collections. Figure 2 is an attempt to stress the preceding statement and to present another manner in which the Humboldt deposit may be compared with similarly studied deposits elsewhere. It also illustrates the influence of changes in lithology on the abundance of Mollusca. There is an approximate threefold increase from collection 17 to collection 16, and over a tenfold increase from collection ten to collection nine, both of which correspond to changes in lithology.

Paleoecology

Methods of interpretation.—A preliminary examination of the list of species in table 1 establishes the freshwater environment of the Humboldt fauna. For the present it should be pointed out that the fauna is remarkable for the absence of

Coll. Number	Number of Individuals	Percent Total	10 20 30 40 50 60 70
1	0	0.00	
2	175	17.38	
3	120	11.74	
4	102	10.20	
5	123	12.30	
6	313	30.69	
7	302	29.90	
8	310	31.00	
9	362	36.20	
10	147	14.70	
11	175	17.50	
12	129	12.90	
13	130	12.32	
14	134	13.20	
15	118	11.57	
16	92	9.20	
17	25	7.40	
18	0	0.00	

FIGURE 5. Quantitative distribution of *Gyraulus altissimus* in the Humboldt deposit.

land snails which are so often associated with Pleistocene lake deposits. This interesting fact is discussed later in detail.

Before attempting to reconstruct the environment in which the assemblage lived, a proper evaluation of the fauna must be made. *Amnicola leightoni*, *Gyraulus altissimus*, *Helisoma anceps striatum*, and *Valvata tricarinata* are the most significant species, i. e., those which form the largest proportions of the fauna. These species compose more than 20 percent of the fauna in one or more collections and are considered by the writer to be indigenous forms. On the other hand, the remaining species individually compose less than seven percent of the total fauna in any one of the collections and for this reason they are considered to be transported forms, i. e., those which normally lived in a freshwater environment somewhat different from the environment indicated by the indigenous forms. In the following discussion, they are called nonindigenous forms.

The paleoecological information in the following paragraphs is summarized from the works of Baker (1910, 1911, 1916, 1918, and 1928), Berry (1943), La Rocque (1952), Mattox (1938), Moffett (1943), and Morrison (1932).

Indigenous species.—*Amnicola leightoni* is an extinct species; therefore, the only ecologic information available is inferred from that of its close relative,

Coll. Number	Number of Individuals	Percent Total	10 20 30 40 50 60 70
1	0	0.00	
2	76	7.55	
3	52	5.10	
4	26	2.60	
5	36	3.60	
6	147	14.41	
7	206	20.39	
8	308	30.80	
9	198	19.80	
10	39	3.90	
11	40	4.00	
12	34	3.40	
13	25	2.37	
14	32	3.15	
15	36	3.53	
16	20	2.00	
17	2	0.59	
18	0	0.00	

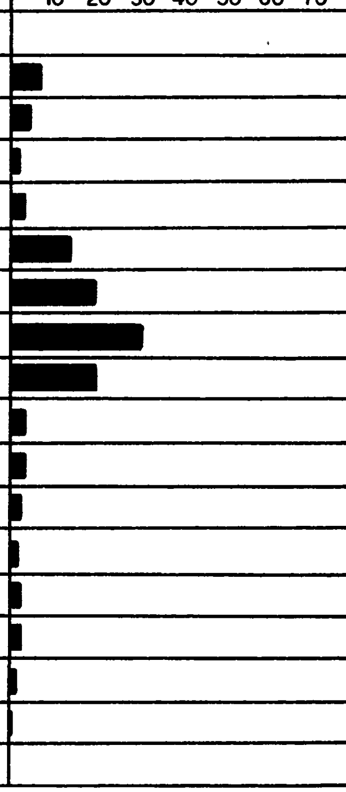

FIGURE 6. Quantitative distribution of *Helisoma anceps striatum* in the Humboldt deposit.

A. limosa (Say). *A. limosa* has been reported from a variety of habitats such as creeks, rivers, and fresh- and brackish-water lakes. It is capable of surviving in water from a few inches to ten ft in depth and appears to prefer bottom sediments characterized by a high percentage of sand. It is most abundant where there are thick beds of *Chara*, *Potamogeton*, *Vallisneria*, and *Elodea;* however, these plants are not used as food but harbor rich colonies of diatoms that the amnicolids eat. The species has also been observed feeding on slime, algae, and minute detritus of the top layer. Its outstanding enemies are fish. The pH for *A. limosa* is 7.95, and the fixed carbon dioxide ratio is 30.56 ppm.

A detailed examination of figure 4 indicates that the ecology of *A. leightoni* closely approximates that of *A. limosa.* The graph illustrates that *A. leightoni* was capable of surviving in a creek or river and in a lake; however, the conspicuous concentration of individuals in the marl (unit 7) suggests that they were better suited to the lake habitat for it was in this environment that they flourished and attained their greatest abundance.

Gyraulus altissimus is also an extinct species, except in localities far to the north and west of Ohio. It is possible to infer ecologic conditions from its close relative, *G. arcticus* ("Beck" Möller) which has been observed in small lakes with quiet water and abundant vegetation. La Rocque states that from its association with other species found both in Pleistocene and living faunas, it may be inferred that *G. altissimus* was a species of small lakes with a wide pH and fixed carbon dioxide range. The following figures for *G. arcticus* appear to support La Rocque's conclusions: pH 8.37, fixed carbon dioxide 25.75 ppm. In the Humboldt deposit there is a definite preference for the lake habitat and for conditions accompanying marl deposition.

Helisoma anceps striatum is an extinct form but from its associations with other species it may be inferred that it is predominantly a lake form, probably living in shallow water. The species has been recorded as common in Tomahawk Lake, Wisconsin, where it occurs on drifted logs and on sand and pebbles in shallow water. It also inhabits sheltered bays and exposed shores but there is a definite preference for the latter environment. Baker (1928) states that the form is an inhabitant of lakes that lived in the cold waters immediately after the retreat of the ice sheet. In the Humboldt deposit, quantitative distribution indicates that the lake habitat was preferred and that marl deposition permitted the form to flourish best.

Valvata tricarinata is a species of rivers, lakes, and permanent ponds, particularly where there is abundant vegetation. It is found on all varieties of bottoms and in all depths down to 18 ft. It is usually associated with the filamentous algae *Oedogonium* and *Cladophora*, and has been observed on *Vaucheria* upon which it was apparently feeding. It is preyed upon by numerous varieties of fish. Its pH range has been given as 7.16 to 8.37 and its fixed carbon dioxide ratio as 8.16 to 30.56 ppm. It reflects to a marked degree changes in the character of bottom sediments (fig. 3). It may be stated with some assurance that it prefers habitats where the bottom sediments are more or less firm and will enable the individuals to move freely about. In the Humboldt deposit they are much more numerous in the calcareous silts, again exhibiting their preference for compacted bottom sediments. With increasing marl deposition the species becomes less abundant.

Pisidium compressum is found in a variety of habitats, all of which have relatively firm bottoms. The typical form is confined principally to creeks and rivers, in water two to 6.3 m deep. It is a burrowing form and feeds on detritus and plankton. Species of *Pisidium* serve as food for many varieties of fish. The following figures have been given for this species: pH 7.0 to 8.37, fixed carbon dioxide 9.3 to 30.56 ppm.

Pisidium nitidum pauperculum has been collected in one and one-half to eight ft of water on sand and mud bottoms in Oneida Lake, New York. Baker (1928) lists the following specific habitats for Wisconsin: mud bottom, large lake, 1.5 m; sand and gravel bottom, 1.5 to 1.7 m; medium-sized lake, mud bottom, 1.2 to 3.4 m; sandy mud bottom, 1 m. The pH for this species is 7.0 to 8.0 and the fixed carbon dioxide 9.3 to 24.73 ppm. It burrows into the bottom sediments and feeds on detritus and plankton.

These two species of *Pisidium* are much more abundant than the remaining species of the genus in the deposit studied and reflect to a marked degree changes in lithology. The indigenous nature of these forms is indicated by their close correlation with lithologic changes. During deposition of the silt in units four, five, and six, the bottom was probably more or less firm and compacted, enabling the small mollusks to burrow into the bottom where only their siphons remained uncovered. In the upper part of unit six there is an increasing amount of marl, and a corresponding decrease in numbers of ***Pisidium***. In the lower part of unit seven the pelecypods decrease to less than one percent and then disappear entirely, probably because the marl bottom was too soft for shallow burrowing.

Nonindigenous species.—Little information is available concerning the ecology of *Campeloma rufum*. It appears to have lived in quiet, shallow water along the margins of the streams which flowed into the main body of water near Humboldt, and was probably transported into the deposit after death. It has been recorded from both lakes and streams in water one to six ft deep, from a variety of bottoms ranging from mud to sand, with or without vegetation

The small freshwater limpet *Ferrissia tarda* appears to be characteristic of cold, shallow, rapidly flowing streams with rocky bottoms. It has also been found on dead Naiad shells and debris. It seldom, if ever, strays from its preferred habitat, very rocky bottom, swift current, cold water six to 15 in. deep. It is evidently not an indigenous form in the Humboldt deposit. It probably lived in one or more of the streams draining into the lake.

Fossaria obrussa decampi has been collected along the swampy shores of a small bay in Tomahawk Lake, Wisconsin, in shallow water a few inches to a foot deep, on soft, sticky mud, with an abundance of algae. Its pH range is 7.42 to 7.7, fixed carbon dioxide 10.65 to 18.87 ppm. In the Humboldt area, it appears to have lived in marshy places along the margins of streams but possibly also along the margins of the lake where water was very shallow and the bottom muddy. Its scarcity may be an indication that such conditions were not common along the shores of the lake.

The widely distributed planorbid *Helisoma trivolvis* is always an inhabitant of quiet, even swampy and stagnant bodies of water, and usually occurs among vegetation. It is an obvious intruder in the Humboldt deposit and probably lived in the streams flowing into the lake. It has been collected from similar habitats, i. e., in protected pools on the margins of streams, filled with algae, and with abundant animal life.

Menetus opercularis multilineatus is a species for which no ecologic data are available. Its scarcity in the Humboldt deposits appears to indicate that it did not live in the lake but was transported, possibly from nearby streams.

Physa gyrina can exist in a variety of habitats, but it appears to be characteristic of slow-moving and stagnant bodies of water, usually on a mud bottom. It has also been found in overflows from large rivers and in small ponds behind river and lake beaches. Its pH is given as 7.1 to 8.37, fixed carbon dioxide 9.5 to 25.75 ppm. In the Humboldt deposit its numbers indicate that it is an intruder, probably washed in by streams.

Promenetus exacuous occurs in quiet, shallow water two to five ft deep on all varieties of bottoms; however, it is most abundant on sand and mud. It is found in habitats with thick vegetation and has been collected clinging to driftwood, dead leaves, and lily pads. It is also known to inhabit mud flats near the margins of small mountain streams of cold, clear water. Its pH range is given as 7.0 to 7.64, fixed carbon dioxide 9.3 to 22.5 ppm. It is associated with the algae *Cladophora fracta* and ***Oedogonium***, and has been observed feeding on the dead leaves of *Typha angustifolia*. It is eaten by ***Eupomotis gibbosus*** (Linn.), the common Pumpkinseed. The presence of this small planorbid is best explained by assuming that it lived in quiet water on the mud flats near the margins of the streams which drained into the lake at Humboldt. It may have lived in the lake itself but if so, it did not flourish there.

Sphaerium striatinum is a burrowing form that lives in both streams and lakes.

It has been reported from swiftly flowing rivers but in shallow water near shore on a sandy mud bottom. In Oneida Lake, New York, it was found in two to three ft of water on a sandy bottom with occasional boulders, and in one to three ft of water on hard sand bottom. It feeds on detritus and plankton and is eaten by fish. Its scarcity probably indicates that it did not live in the lake itself but in streams flowing into it.

Little ecological information is available for *Sphaerium sulcatum.* It has been collected in Oneida Lake, New York, on mud in eight to 13 ft of water; in rivers in Wisconsin, on sand, mud, gravel, and mixed sand and gravel bottoms, in shallow water. It has a wide pH range, 6.9 to 8.37, and fixed carbon dioxide range, 9.3 to 25.75 ppm. Its scarcity also indicates that it lived in streams flowing into the lake.

Pisidium nitidum has been collected on a clay bottom in five ft of water, on a mud bottom in approximately 17 ft of water, and on a soft sand bottom in shallow water. Because of its scarcity, it is thought to have lived in streams flowing into the lake.

Pisidium obtusale has been collected on mud in eight and 11 ft in Oneida Lake, New York. No other ecological information seems to be available for this species. It is also thought to have lived in streams and not in the lake itself.

Pisidium variabile inhabits both rivers and lakes. It occurs frequently in water from one to 13 ft deep, burrowing in gravel, sand, clay, and mud, but is more abundant in mud where the water is four to 11 ft deep. The following figures have been given for this species: pH 5.72 to 8.37, fixed carbon dioxide 1.72 to 30.56 ppm. It feeds on detritus and plankton and is eaten by numerous varieties of fish. Its small numbers indicate that it lived in streams flowing into the lake and not in the lake itself.

Absence of land snails.—The majority of fossiliferous Pleistocene deposits are characterized by the presence of terrestrial gastropods in appreciable numbers, e. g., La Rocque (1952, p. 12) reports six species of land snails and 15 species of freshwater snails for the Orleton Mastodon site in Madison County, Ohio. Leonard (1953, p. 372) collected 15 species of land snails and only five species of aquatic gastropods in a Wisconsin loess at Cleveland, Ohio. Thornbury and Wayne (1957, pp. 5–27) give quantitative data for numerous deposits in Indiana, all of which contain large percentages of land snails. Other examples exist but are too numerous to be cited.

The Humboldt fauna is remarkable for the absence of land snails, a fact which serves to distinguish it from numerous other Pleistocene faunas. It is impossible to state that there is a total absence of land snails in the Humboldt deposit for this study is confined to one series of samples from one station. It may be stated, however, that if land snails inhabited the slopes some would have been preserved in the deposit. Also, if the slopes were populated there would probably be a concentration of land genera near the shoreline. Field evidence indicates, however, that the Humboldt deposit was sampled over 150 ft from shore. Evidently this distance is too great to expect the accumulation of large numbers of land snails. Nevertheless, it is noteworthy that no land snails were present in over 16,000 specimens examined.

Conclusions.—The molluscan assemblage suggests a freshwater lake two to ten ft deep with abundant vegetation that served as food and cover for some species and harbored colonies of microscopic plants and animals that served as food for others. The pH varied from seven to eight and the fixed carbon dioxide ratio was approximately 24 ppm. A change in the pH and fixed carbon dioxide probably accompanied the change from silt deposition to marl deposition; however, there is no paleontological evidence to support this assumption.

The wide occurrence of laminated silts as far south as Valley School suggests that the lake occupied a large part of Buckskin Creek valley, approximately three mi in length and one-half mi wide.

Mollusca are known to have a variety of enemies, e. g., insects, birds, fish, and crustaceans. Their outstanding enemies are fish and the diet of some fish consists of 50 to 60 percent mollusks. It may be assumed that insects, birds, and crustaceans were present either in the lake or the immediate vicinity; however, there is direct evidence for the presence of fish. Naiades presuppose the presence of fish, and from the abundance of Naiades it may be inferred that numerous fish were present to feed on the mollusks.

The stratigraphy and paleoecological data furnish valuable information in reconstructing the history of the lake at Humboldt. The large, thick-shelled Naiades in the silts indicate moving water; however, these forms are replaced in the marl by the comparatively small, thin-shelled Naiad *Anodonta* sp., a quiet-water form. Therefore, the silts represent deposition during the early history of the lake when it was relatively shallow and there was active accumulation of glacial meltwater to provide sufficient current for the large, thick-shelled Naiades. The marl probably represents deposition in a somewhat deeper, more mature lake.

The high lime content of the sediments at Humboldt was probably derived from the extensive deposits of till and outwash in the valley. Little or no lime could have been derived from the bedrock for it is predominantly Ohio shale and has a low calcium carbonate content.

A modern parallel for the lake at Humboldt may be found in Sodon Lake, Oakland County, Michigan (Cain, Segadas-Vianna, and Bunt, 1950), although Sodon Lake appears to be in a later stage of development and has a more abundant fauna.

Age and Correlation

La Rocque and Forsyth (1957, p. 86) state:

> In Ohio, age determinations on the basis of molluscan faunules must be made with extreme caution and on a conditional basis for three reasons. In the first place, few assemblages have been studied in sufficient detail to serve for comparison with newly discovered faunules. Secondly, certain species, hitherto considered characteristic of a particular part of the Pleistocene, have later been recorded for younger or older sediments, which has led to modification of ideas on their stratigraphic significance. Thirdly, species of proven stratigraphic significance in other states, for example in Kansas, where so much has been accomplished by Leonard, may have a different value in Ohio because of different factors influencing the dispersal of Mollusca.

With these reservations in mind, all that can be done with the Humboldt fauna, from the standpoint of age determination, is to assemble all available information on the stratigraphic range of the species in Ohio and elsewhere and to draw tentative conclusions from this information. Despite these restricting conditions it is still possible to arrive at a fairly definite age for the Humboldt fauna.

The stratigraphic range of each of the Mollusca, so far as known at present, is shown in table 2. It should be pointed out that it contains three species, possibly more, that are not now living in Ohio. Two of these, *Amnicola leightoni* and *Gyraulus altissimus*, are entirely absent from living assemblages in Ohio. The other is represented in Ohio by the typical form but its variety, *Helisoma anceps striatum*, has not been reported from living faunas in the state.

To postulate an age older than Illinoian for this deposit seems unreasonable. Twelve species in the deposit are not represented in Yarmouthian deposits and fifteen have not been reported in deposits of Kansan age.

Leonard (1950, p. 41) gives the following stratigraphic ranges for some fresh-water Mollusca collected from Yarmouthian deposits in the midcontinent region of the United States; lower Pliocene to Recent, *Helisoma anceps* (Menke) and *Physa anatina* Lea; Aftonian to Recent, *Fossaria parva* (Lea); restricted to Yarmouthian, *Gyraulus labiatus* Leonard, *Menetus pearlettei* Leonard, and *Gyraulus pattersoni* Baker; Yarmouthian to Recent, *Pisidium compressum* Prime, *Promenetus umbilicatellus* (Cockerell), *Gyraulus similaris* (Baker), *Valvata tricarinata* (Say), *Helisoma* cf. *H. wisconsinense* (Winslow), *Amnicola limosa parva* Lea, *Helisoma trivolvis* (Say), *Sphaerium* sp., *Physa elliptica* Lea, *Valvata lewisi* Currier, and *Ferrissia parallela* (Haldeman). All of the genera mentioned above are also found in the Humboldt fauna; however, the large majority of the species are incongruous. On the basis of this information an age determination older than Illinoian is discarded.

TABLE 2

Stratigraphic range of identified species of the Humboldt fauna

Species	PLIO*	NE	AF	KA	YA	IL	SA	WIS	LIV
Pisidium compressum Prime	N	N	N	B	B	B	B	B	B
Pisidium nitidum Jenyns	N	N	N	N	A	C	C	H	D
Pisidium nitidum pauperculum (Sterki)	N	N	N	N	A	C	C	H	D
Pisidium obtusale (Lamarck)	N	N	N	N	N	N	N	H	D
Pisidium variabile Prime	N	N	N	N	A	C	C	H	D
Sphaerium striatinum (Lamarck)	N	N	N	N	N	N	N	H	D
Sphaerium sulcatum (Lamarck)	N	N	N	N	N	N	N	E	D
Valvata tricarinata (Say)	N	N	N	B	B	B	B	B	B
Campeloma sp., cf. *C. rufum* (Haldeman)	N	N	N	N	N	N	D?	H	D
Amnicola leightoni F. C. Baker	N	N	N	N	N	N	N	E	N
Fossaria obrussa decampi (Streng)	N	N	N	N	N	N	N	E	D
Helisoma anceps striatum (F. C. Baker)	N	N	N	N	N	N	N	E	N
Helisoma trivolvis (Say)	N	N	N	B	B	B	B	B	B
Menetus opercularis multilineatus (Vanatta)	N	N	N	N	N	N	N	H	G
Promenetus exacuous (Say)	N	N	N	N	N	N	N	E	D
Gyraulus altissimus (F. C. Baker)	N	N	N	N	N	N	F?	E	F
Ferrissia tarda (Say)	N	N	N	N	N	N	N	H	D
Physa gyrina Say	N	N	N	N	N	N	N	H	D

*Explanation of symbols

PLIO	Pliocene	SA	Sangamon	D	La Rocque (1953)
NE	Nebraskan	WIS	Wisconsin	E	Baker (1920)
AF	Aftonian	LIV	Living	F	Russell (1934)
KA	Kansan	A	Leonard (1950)	G	Vanatta (1895)
YA	Yarmouth	B	Frye and Leonard (1952)	H	Humboldt deposit only
IL	Illinoian	C	By inference from the existence of an older record.	N	Not recorded

The position of the deposit between two tills suggests the possibility of a Sangamon or Illinoian age. Ten of the 18 species of the Humboldt fauna have not been recorded for Sangamon deposits and 12 have not been recorded for Illinoian deposits. If an age older than Wisconsin is assumed then the stratigraphic range of ten species must be extended to corroborate this assumption. This is unlikely but not impossible, however, for the range of other species has been extended in the past. Nevertheless, the fact remains that, at present, these ten species have not been found in deposits older than Wisconsin in Illinois, Indiana, Ohio, and Kansas. Also, geologic evidence supports a Wisconsin age much more strongly than a Sangamon or an Illinoian one. Therefore it must be concluded that the Humboldt fauna is Wisconsin in age.

In order to avoid an age determination based entirely on the Mollusca, the glacial history of south-central Ohio and Buckskin Creek valley was studied in some detail. A complete understanding of the stratigraphy in the valley is prerequisite to an interpretation of the glacial history. Therefore, a composite stratigraphic section is presented below. Information gathered from an exposure several hundred feet south of the measured section and from a jeep-mounted power auger is incorporated in the section.

Unit	Description	Thickness (feet)
9.	Till, silty and clayey, oxidized brown, calcareous	15
8.	Till, silty and clayey, unoxidized blue-gray, calcareous	17
7.	Clay, smooth and somewhat plastic, generally blue-gray, entirely non-calcareous, contains rich zones of Ohio black shale	24
6.	Peat, containing abundant crushed Mollusca	1/3–2
5.	Marl, clayey, very fossiliferous	3–5
4.	Marl and clay, laminated in places, slightly fossiliferous in upper portion	1–6
3.	Sand and gravel, reddish-brown in places, calcareous	0–5
2.	Till, oxidized brown, silty, calcareous	5–8
1.	Gravel, coarse, stratified	10 +

This gravel appears to be the same as that exposed in an abandoned gravel pit 0.3 mi south of the measured section where it persists to a higher elevation, has in it a well-developed Sangamon soil, and is overlain by a calcareous till that is apparently continuous with the upper till of this section.

The gravel exposed in the abandoned gravel pit and containing the Sangamon soil is undoubtedly of Illinoian age. The till overlying the gravel has a depth of leaching of 50 to 60 in. and has been mapped by Mr. James H. Petro of the Ohio Division of Lands and Soil as "early" Wisconsin, with the meaning suggested by Goldthwait and Forsyth and explained by La Rocque and Forsyth (1957, p. 81). This till appears to be continuous with the uppermost till in the composite section. Also, pebble counts in the basal gravel of the Humboldt section and in the gravel that contains the well-developed Sangamon profile strongly indicate that they are one and the same. If this is true, then the basal gravel in the measured section must also be Illinoian in age and its surface must have been eroded after the soil profile developed, probably by the first advance of the "early" Wisconsin ice. Therefore, it must be concluded that the Humboldt deposit is "early" Wisconsin in age.

Correlation of the Humboldt deposit is difficult for only one deposit has been assigned an "early" Wisconsin age in Ohio, the Sidney Cut, Shelby County (La Rocque and Forsyth, 1957). Although the faunas apparently are of the same age the environments suggested by the Mollusca are very different. The genera represented in the Sidney Cut, with the exception of *Fossaria*, are land pulmonate gastropods whereas the Humboldt fauna is entirely freshwater. Since little can be accomplished by correlation, perhaps comparisons with faunas of known age will serve to substantiate the age determined for the Humboldt fauna.

Baker (1920) has studied approximately 20,000 shells collected by M. M. Leighton from the south end of Rush Lake, Logan County, Ohio. The deposit lies within the limit of "late" Wisconsin drift and is considered to be post-Wisconsin in age. The list of species was revised by La Rocque (1952, p. 22). The Rush Lake fauna closely approximates that of the Humboldt deposit but its affinities are much closer to living faunas than those of Humboldt.

La Rocque (1952) has studied the Mollusca from two layers in the Orleton Mastodon site, Madison County, Ohio. The lacustrine deposits rest on till that has been dated as Cary ("late" Wisconsin) by Goldthwait (1952, pp. 5–9). The list of species (La Rocque, 1952, p. 12) is of interest for comparison with the Humboldt fauna because it is one of the few which includes quantitative data. The differences between the Orleton and the Humboldt lists may well be attributed to the difference in age, the smaller size of the Orleton lake, the longer period of development of the Humboldt lake, and the greater distance of Orleton lake from a major drainage system.

The age of the Humboldt fauna can definitely be stated as Wisconsin, and perhaps just as definitely "early" Wisconsin, for three reasons. First, a Wisconsin age determination is indicated by the presence of ten species that have not, at present, been recorded for deposits older than Wisconsin. Secondly, an "early" Wisconsin age is suggested by the incongruity of the Humboldt fauna with faunas that are "late" Wisconsin or post-Wisconsin in age. Thirdly, the fact that the Humboldt deposit overlies a gravel that has in it a well-developed Sangamon soil and underlies a till that has been mapped as "early" Wisconsin by soil scientists proves rather conclusively that it is "early" Wisconsin in age.

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